Annals of the Academy of Romanian Scientists
Series on Agriculture, Silviculture and Veterinary Medicine Sciences
Online ISSN 2069 – 1149 Volume 4, Number 1-2/2015

LONG TERM EFFECT OF IMPROVEMENT METHODS ON SUBALPINE DEGRADED *Nardus stricta* L. GRASSLANDS

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Abstract. *Researches have been carried out at the Research Station for Mountain Grasslands from Blana, Bucegi, located at 1.800 m altitude (subalpine floor) in order to determine the effect of different improvement methods on degraded Nardus stricta grasslands. With the dry matter yield (DM) there have been made accurate analysis of floristic composition and fodder quality after 19 years since the improvement by different methods. The researches have highlighted the long term effect of improvement methods (organic and chemical fertilisation, reseeding, over-seeding and liming) a subject not so well studied in present time in Romanian Carpathians. The best improvement method was the liming up to 2/3 hydrolytic acidity, over-seeding after harrowing at 1 up to 2 cm deep and organic or organic and chemical fertilisation. In this plot Nardus stricta was replaced by valuable species like Festuca nigrescens, Agrostis capillaris and Poa pratensis. Also the participation of Trifolium repens has grown up to 20-25 %. As a result, the pastoral value increases to 68, the DM yield triples and has a crude protein content of approximately 12 % and a lower fibre and lignin proportion thus increasing the fodder digestibility.*

Keywords: floristic composition, improvement methods, *Nardus stricta* grasslands, quality of fodder.

1. Introduction

Researches concerning the influence of improvement methods on floristic composition and fodder quality from mountain grasslands are numerous in Romanian Carpathians, but mostly of them have had results only for 3 to 5 years, according to usual experimental protocols (Puscaru *et all.*, 1956, Barbulescu and Motca, 1983). Results over longer periods are generally fewer and almost absent on higher grasslands such as the subalpine ones from Carpathians, located in *Pinus mugo* floor at 1800 m altitude (Maruşca *et all.* 2010). In this climatic

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conditions and vegetation period at higher altitude, the evolution of sward and fodder quality in relation with the improvement methods are much more different than the lower grasslands with favourable conditions.

For this reason it has been raised the problem of researches carried out over longer periods on the degraded *Nardus stricta* grasslands from high mountain region, that require improvement.

2. Material and method

The experience was carried out at the Research Station for Mountain Grasslands from Bucegi Mountains, at 1.800 m altitude in subalpine floor on degraded *Nardus stricta* grassland (40 % *N. stricta*).

Experimental plots are:

A Factor: Fertilization

1. Chemical fertilisation

Phase I: 1996 - 50 kg /ha P_2O_5 +50 kg/ha K_2O;
1997 - 50 kg /ha P_2O_5 +50 kg/ha K_2O;
1998 - 50 kg /ha P_2O_5 +50 kg/ha K_2O;

Phase II: 2004 - 150 kg /ha N + 100 kg /ha P_2O_5 +100 kg/ha K_2O;
2005 - 100 kg /ha N;
2006 - 50 kg /ha N;

Phase III: 2012 - 150 kg /ha N + 100 kg /ha P_2O_5 +100 kg/ha K_2O;
2013 - 100 kg /ha N;
2014 - 50 kg /ha N;

2. Chemical and organic fertilisation

Phase I: 1996 - 150 kg /ha N + 50 kg /ha P_2O_5 +50 kg/ha K_2O;
1997 - 100 kg /ha N + 50 kg /ha P_2O_5 + 50 kg/ha K_2O;
1998 - 50 kg /ha N + 50 kg /ha P_2O_5 +50 kg/ha K_2O;

Phase II: 2004- paddocking 5 nights one cow/6 m^2 + 100 kg /ha P_2O_5;

Phase III: 2011 - paddocking 5 nights one cow /6 m^2 + 100 kg /ha P_2O_5;

3. Organic fertilisation

Phase I: 1995 - paddocking with one sheep/1 m^2 for 5 nights;

Phase II: 2004 - paddocking with one sheep/1 m^2 for 5 nights + 100 kg /ha P_2O_5;

Phase III: 2011 – paddocking with one cow/6 m^2 for 5 nights + 100 kg /ha P_2O_5;

B Factor: Sward

1. Natural (*Nardus stricta* 60 %);
2. Over-seeding in 1996, after spraying in 1995 and harrowing (1-2 cm);
3. Reseeding in 1996 after spraying 1995 and milling (10-12 cm);

C Factor: Liming

1. No liming;
2. Liming up to 2/3 hydrolytic acidity (approx. 7,5 t/ha CaO)

The harvesting of experimental plots for determining the yield and taking the samples for chemical analyses were done once a year, at a beginning of August on 2 square meters from the total 18 m^2 of each experimental plot, the rest

of the surface was grazed by dairy cows. In this way, by grazing, trampling and animal manure we have get closer to the reality from those grasslands, compared to the usual system of harvesting by mowing and the presentation of the results with approximate conclusions for the grazing regime.

We would like to mention that the over and reseeded species (*Phleum pratense* and *Festuca pratensis*) have not produced seeds for auto-seeding, so it can be noticed their longevity in sward.

3. Results and discussion

Dry matter yield

For starter it was calculated the factors influence on dry matter yield (DM), especially for the ones with a signification (Table 1).

Table 1. Influence of fertilization (A), liming (C) and combination sward type – liming (BxC) on DM yield, Blana – Bucegi, 2014

Factors	DM yield		Difference	Signification
	t/ha	%	+ -	
A. Fertilization				
A1 Chemical	1,42	100	Control	-
A2 Organic + chemical	2,45	173	1,03	**
A3 Organic	3,11	219	1,69	***
C. Liming				
C1 no liming	1,99	100	Control	-
C2 liming up to 2/3 hydrolytic acidity	2,67	134	0,68	***
B (grassy carpet) x C (liming)				
B1 natural x C1	1,76	100	Control	-
B2 over-seeded x C1	2,29	130	0,52	
B3 re-seeded x C1	1,91	108	0,15	
B1 x C2	3,00	170	1,23	***
B2 x C2	2,81	159	1,05	***
B3 x C2	2,20	125	0,43	***
DL:	A	C	B x C	
5 %	0,50	0,32	0,56	
1 %	0,80	0,43	0,75	
0,1 %	1,29	0,57	0,98	

From showed data it results that the organic fertilisation in 3 stages, after 19 years of influence is with 219 % higher than the chemical fertilisation and the liming ensures a DM yield with 134 % higher compared to the plots not limed, both factors are very significant.

Floristic compositions

As a result of improving the sward by liming and sowing, in 1996, followed by three stages of fertilisation the grassy carpet had undergone profound modifications (Table 2).

Table 2. Floristic composition of the experimental plots (Blana Bucegi, 2014)

Species / Plot	111	211	311	112	212	312	121	221	321	122	222	322	131	231	331	132	232	332
Grasses total	**76**	**65**	**65**	**68**	**63**	**55**	**85**	**70**	**78**	**88**	**68**	**62**	**85**	**75**	**72**	**80**	**70**	**70**
Phleum pratense	-	10	3	-	1	2	-	18	18	28	30	17	-	7	13	2	13	20
Festuca pratensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Nardus stricta	4	-	-	1	-	-	2	-	-	-	-	-	3	-	-	-	-	-
Festuca nigrescens	8	8	11	27	14	-	1	18	10	20	10	5	10	4	1	8	10	10
Agrostis rupestris	13	-	3	2	-	5	12	5	4	7	3	1	12	2	4	8	4	1
Agrostis capillaris	4	7	5	-	-	4	15	23	32	20	17	27	18	31	40	41	32	23
Poleum alpinum	2	4	4	4	2	3	+	+	3	-	-	5	2	6	4	3	1	4
Poa nemlis	6	5	7	2	1	2	10	5	5	3	3	1	13	9	2	10	6	4
Poa pratensis	+	25	27	32	45	37	-	2	3	5	-	7	-	3	3	-	2	7
Anthoxanthum odoratum	4	2	+	+			8	-	-	-	-		5	1	1	1	+	+
Deschampsia flexuosa	17	4	1	-		2	33	1	3	1	1	1	22	9	+	2	2	1
Legumes *Trifolium repens*	**4**	**20**	**17**	**11**	**22**	**25**	**+**	**20**	**10**	**8**	**17**	**23**	**3**	**15**	**14**	**7**	**23**	**17**
Other species	**20**	**15**	**18**	**21**	**15**	**20**	**15**	**10**	**12**	**7**	**15**	**15**	**12**	**10**	**14**	**13**	**7**	**13**
Potentilla aurea	8	1	2	5	1	1	10	1	2	2	1	2	9	2	8	4	1	2
Ligusticum mutellina	10	7	8	9	4	7	4	6	3	4	6	2	1	2	2	1	2	2
Ranunculus nemorosus			1						+	+					1			1
Polygonum bistorta												2					1	
Heracleum sarosticum	+	+	1	1	+			+	+	+		+	1	3	1		1	
Campanula alvestris								1										
Campanula rotundifolia	1	1	2	4	1	3	1		+	1	1	+	1	1	1	2	1	1
Viola declinata									+						1	1		
Taraxacum officinale	1	4	6	2	4	8		2	7	+	1	7		2	2		2	6
Rumex acetosella		1	1		2	1						1						
Achillea ratana		1			2													
Acclamella vulgaris			+		1					+	2	1			+	1		

After 19 years since seeding it can be noticed the presence of *Phleum pratense* species, Favorit variety with a participation of 17-30 % in over-seeded and limed plots without auto-seeding, this prove the exceptional longevity of this variety in extreme climatic conditions.

Likewise it can be noticed the appearance and the spreading of *Poa pratensis* species in natural sward and *Agrostis capillaris* species in the plots harrowed at 1-2 cm deep in order to over-seeding and milling at 10-12 cm for reseeding.

Longevity of some seeded species such as *Phleum pratense* and the appearance and spreading of a few valuable spontaneous species as *Poa pratensis, Agrostis capillaris* and *Festuca nigrescens* is due to fertilisation, liming and rational utilisation.

Pastoral value of the experimental plots and the factor influence are presented in table 3.

Table 3. Pastoral value (PV) of experimental plots (Blana Bucegi, 2014)

Plot	Pastoral value	Appreciations	Differences	%
111	23	Low	Control 111	100
211	60	Good	+ 37	261
311	53	Good	+ 30	230
112	55	Good	Control 112	100

212	61	Good	+ 6	111
312	57	Good	+ 2	104
121	23	Low	Control 121	100
221	66	Good	+ 33	287
321	62	Good	+ 29	270
122	64	Good	Control 122	100
222	68	Good	+ 4	106
322	66	Good	+ 2	103
131	29	Average	Control 131	100
231	53	Good	+ 24	183
331	60	Good	+ 31	207
132	50	Good	Control 132	100
232	63	Good	+ 13	126
332	65	Good	+ 15	130
Mean of factors				
100	41	Average	Control 100	100
200	62	Good	+ 21	151
300	61	Good	+ 20	149
010	52	Good	Control 010	100
020	58	Good	+ 6	112
030	54	Good	+ 2	104
001	48	Average	Control 001	100
002	62	Good	+ 14	129
Experience Mean				
000	55	*	*	*

The best plot, regarding the pastoral value, was 222 meaning the organic and chemical fertilisation, over-seeding and liming, registering 68 points followed by 221 and 322 plots with 66 points.

From point of view of factors influence the highest growth was recorded in case of combined fertilisation (organic plus chemical products) and organic with an average increase of 150 % compared to chemical fertilisation, followed by liming with 129 % compared to the plot not limed and over-seeded with 112 % compared to natural sward.

Chemical composition of fodder

Fertilisation system (factor A) had the greatest influence on the chemical composition of fodder from studied grasslands (Table 4).

Table 4. Chemical composition of fodder in relation with the fertilization system Blana – Bucegi, 2014

Specification	Fertilisation system (Factor A)	Content g/100g	%	Difference + -	Signification
Crude protein (CP)	1. Chemical	9,68	100	control	
	2. Organic + chemical	10,05	104	+0,37	
	3. Organic	11,85	122	+2,17	**
Ash	1. Chemical	6,08	100	control	
	2. Organic + chemical	6,74	111	0,66	**
	3. Organic	7,56	124	1,48	***
Crude cellulose (CC)	1. Chemical	39,34	100	control	
	2. Organic + chemical	38,96	99	-0,38	
	3. Organic	36,33	92	-3,01	oo
ADF	1. Chemical	41,87	100	control	
	2. Organic + chemical	41,31	99	-0,56	
	3. Organic	39,26	94	-2,61	oo
ADL	1. Chemical	5,61	100	control	
	2. Organic + chemical	5,24	93	-0,37	o
	3. Organic	4,90	87	-0,72	oo

DL:	CP	Ash	CC	ADF	ADL
5 %	1,15	0,37	1,76	1,59	0,33
1 %	1,75	0,56	2,67	2,40	0,51
0,1 %	2,80	0,90	4,30	3,86	0,82

Thus, as a result of organic fertilisation, the fodder has the highest content of crude protein (11,85 %) more with 122 % compared to chemical fertilisation. It is the same in the case of ash content, higher in plots organic plus chemical fertilised and with organic manure. The lowest content of CC, ADF and ADL is present in the case of organic fertilisations compared to chemical fertilisation, plots that are presenting a superior forage quality.

Fertilisation type and the liming had also an important influence as well for the crude protein, yield per hectare. CP from improved grasslands is greater than the one from control plot (Table 5), with an important benefit for animals, by ensuring a good energy - protein balance in fodder (Nichita, 1984).

Table 5. Influence of fertilisation and liming on crude protein yield, Blana-Bucegi, 2014

Specification	CP yield		Difference + -	Signification
	kg/ha	%		
A. Fertilization				
1. Chemical	146	100	control	
2. Organic + chemical	252	172	208	***
3. Organic	320	219	276	***
DL 5 % = 55 DL 1 % = 83 DL 0,1 % = 133 kg/ha				
C. Liming				

1. No liming	205	100	control	
2. Liming up to 2/3 Hidr. Acid.	275	134	70	***
DL 5 % = 33 DL 1 % = 44 DL 0,1 % = 59 kg/ha				

A final analysis was focused on organic matter digestibility (OMD), in this case the organic fertilisation and liming have provided a yield with 104 -111% higher compared to control plot (Table 6).

Table 6. Digestibility indices of OMD in relation with fertilisation and liming, Blana-Bucegi, 2014

Specification	OMD		Differences	Signification
	indices	%	+ -	
B. Fertilization				
1. Chemical	44,38	100	control	
2. Organic + chemical	45,62	103	1,24	
3. Organic	49,16	111	4,75	*
DL 5 % = 3,26 DL 1 %= 4,95 DL 0,1 % = 7,95				
C. Liming				
1. No liming	45,38	100	control	
2. Liming up to 2/3 Hidr. Acid.	47,39	104	2,01	*
DL 5 % = 1,89 DL 1 %= 2,55 DL 0,1 % = 3,40				

Shown data are highlighting the known results about the importance of organic fertilisation and liming on grasslands from high mountain area on the quality of fodder.

CONCLUSIONS

1. Dry matter yield of improved grasslands was stimulated by organic and combined fertilisation especially on plots limed, with a natural sward or over-seeded.
2. Generally speaking, the floristic composition of studied grasslands, after almost two decades of factors influence, have highlighted the longevity of sown species *Phleum pratense*, the appearance and dominance from spontaneous vegetation of *Poa pratensis* species in present sward and of the species *Festuca nigrescens* and *Agrostis capillaris* in over and reseeded plots and the stimulation of *Trifolium repens* species in limed plots organic fertilised.
3. The highest pastoral value was registered on the plot fertilised in a combined system (organic plus chemical) and organic, on over-seeded and limed plots.
4. The fodder quality expressed by the protein and fibres content in with a direct effect on digestibility of feeds, has underlined the long term effect of paddocking and liming.

5. The degraded subalpine *Nardus stricta* grasslands can be improved in a first stage by liming, over and reseeding, were is possible; a initial chemical fertilisation followed by organic one by paddocking and after a conversion period, the grasslands can be transferred to a biological agriculture.

REFERENCES

1. Bărbulescu, Motcă Gh., 1983, Păşunile munţilor înalţi, Ed. Ceres, Bucureşti
2. Maruşca T., Bărbos M.I., Blaj V.A., Cardaşol V., Mocanu V., Rusu M., Secelean I., 2010, Tratat de reconstrucţie ecologică a habitatelor de pajişti şi terenuri degradate montane, Ed. Universităţii "Transilvania", Braşov
3. Puşcaru D., Puşcaru-Soroceanu E., Paucă A., Şerbănescu I., Beldie Al., Ştefureac Tr., Cernescu N., Saghin N., Creţu V., Lupan L., Taşenco V., 1956, Păşunile alpine din Munţii Bucegi, Ed. Academiei Republicii Populare Române
4. Nichita Georgeta, 1984, Nutriţia, factor fundamental în rentabilizarea producţiei animaliere, Ed. Facla, Timişoara